Vision Series:
Power Management

International Rectifier

Driving Power Performance To The Next Level

Driving Power Performance To The Next Level

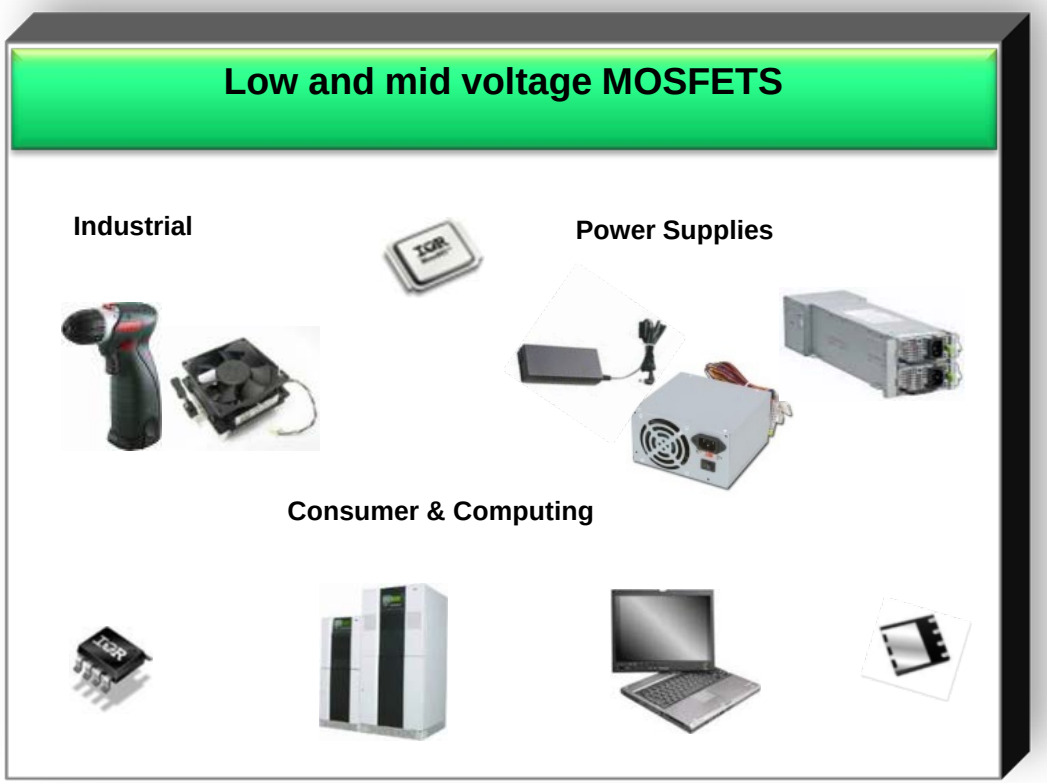
Power designers continue to drive for higher performance and smaller size.

International Rectifier is a world leader in power management technology. IR's analog- and mixed-signal ICs, advanced circuit devices, integrated power systems, and components enable high-performance computing and reduce energy waste from motors, the world's single largest consumer of electricity.

This review of current power management solutions and discussion of near term emerging materials demonstrates that IR is uniquely positioned with advanced technologies and packaging techniques to enable power designers to meet their size and efficiency challenges 5 year out

Application Specific Power MOSFET Silicon

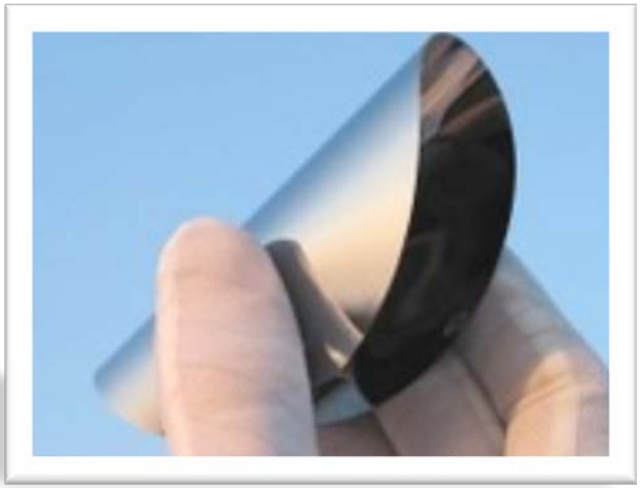
Designers must look carefully at the data sheet



Application specific silicon required for

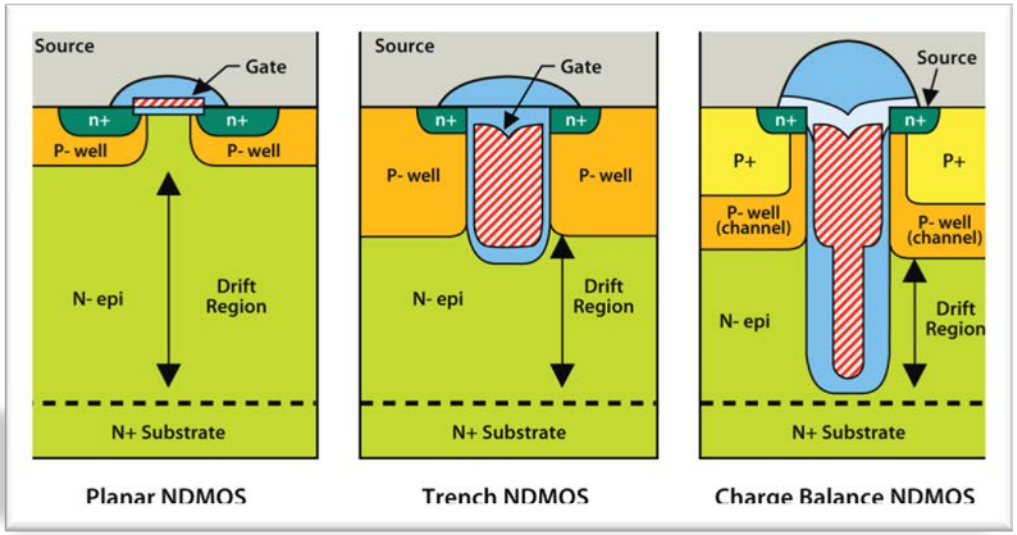
- Low conduction losses – low Rds(on). Application is normally Oring, Hot Swap, Motors, Battery protection
- Fast switching – Low Figure of Merit (FOM) Rds x Qg. Application is normally DC-DC converters

Power MOSFET Silicon Next Steps

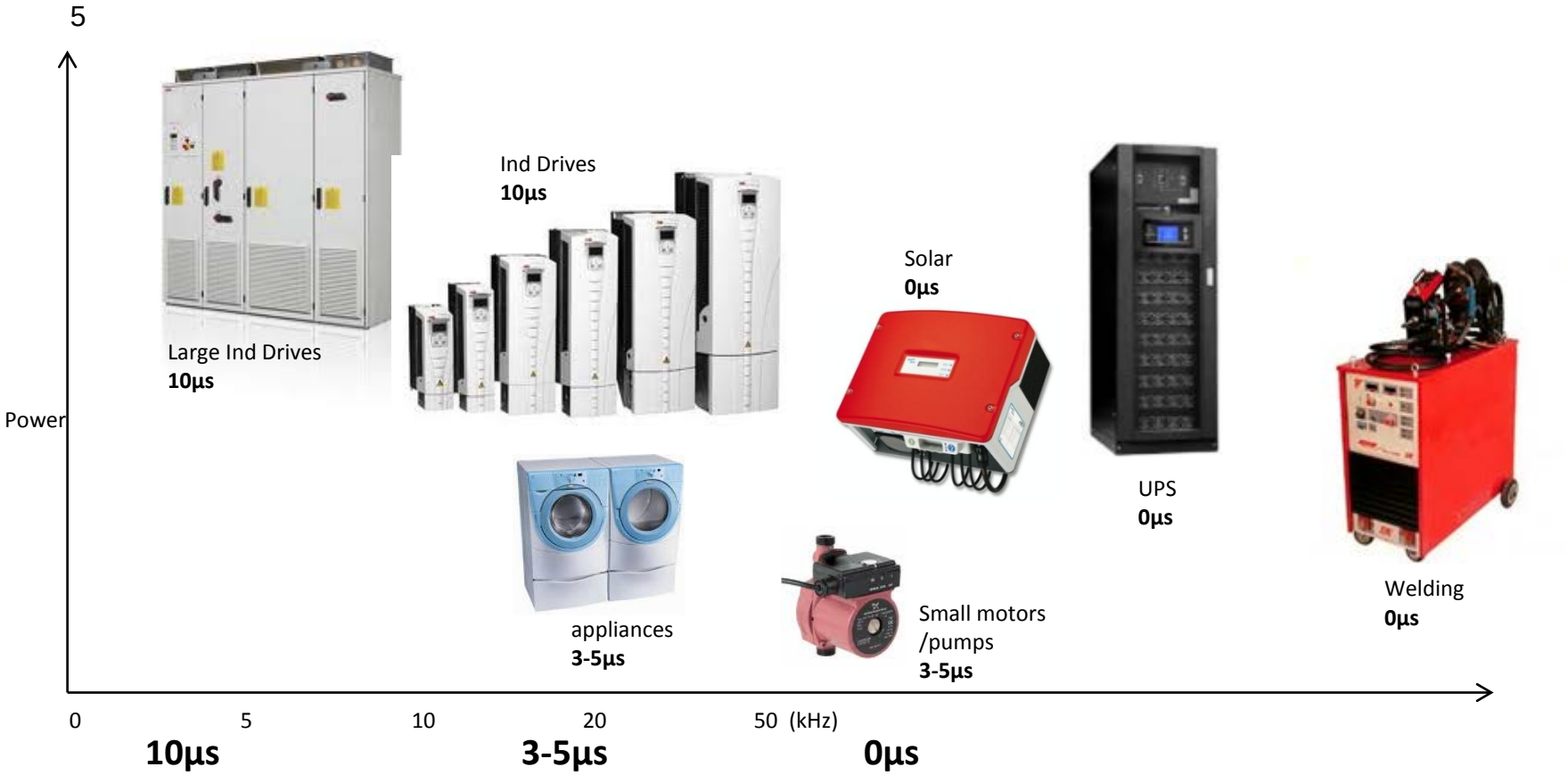


- For low voltage MOSFETs Rds(on) can be reduced by thinning the wafer.
  - Bulk silicon is major contributor of Rds(on)
  - Thin wafers require specialized handling techniques

- New complex MOSFET structures utilize new wafer fab tools



Application Specific IGBTs



Industrial **Light Industrial/Consumer** **Inductor on output**

Low switching frequency

IGBT Goal: Low Conduction losses & rugged operation

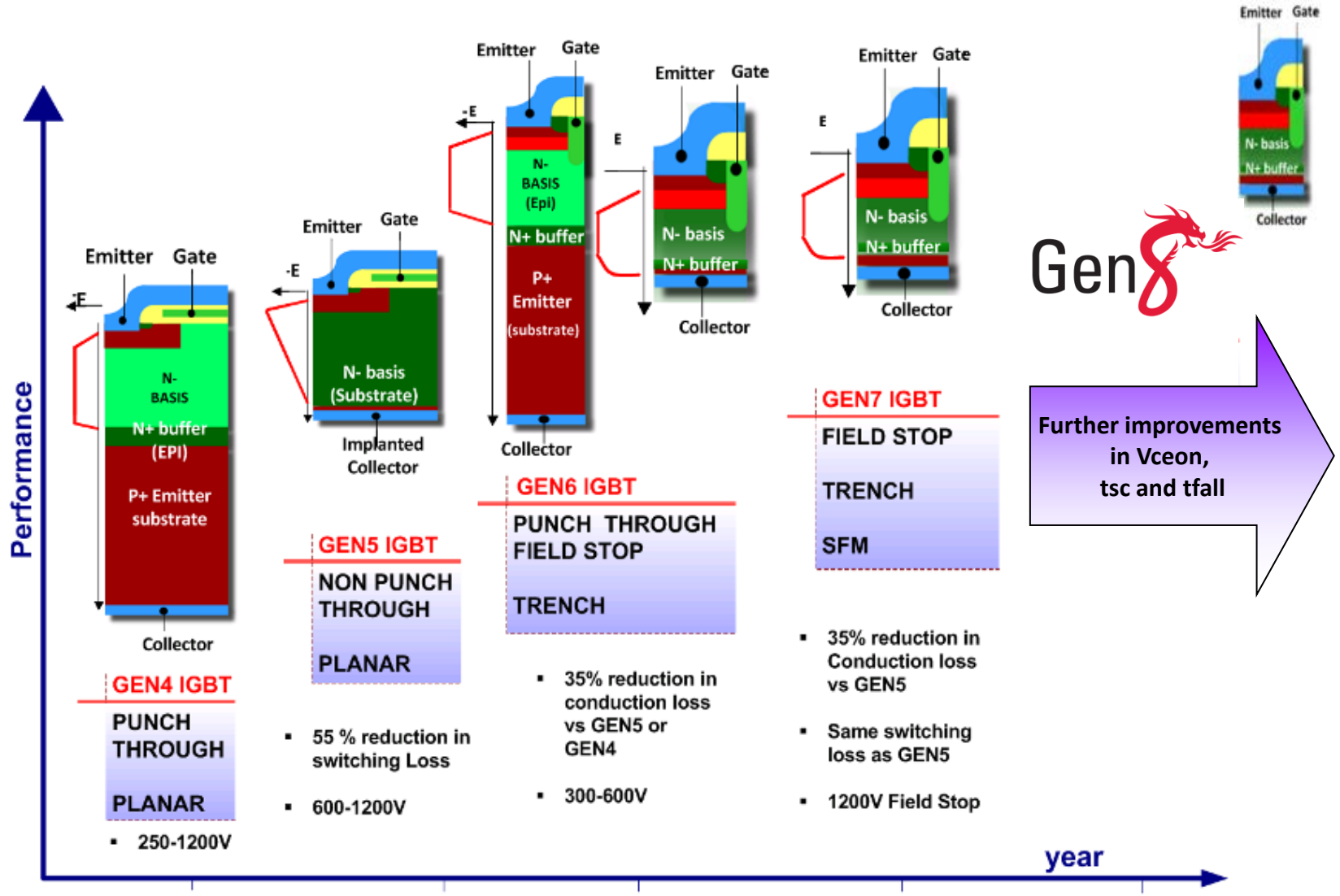
Requires: Short Circuit Capability & Low $V_{CE(ON)}$

High switching frequency

IGBT Goal: Low switching losses

Requires : Low E_{TS}

International Rectifier IGBT Platform Development



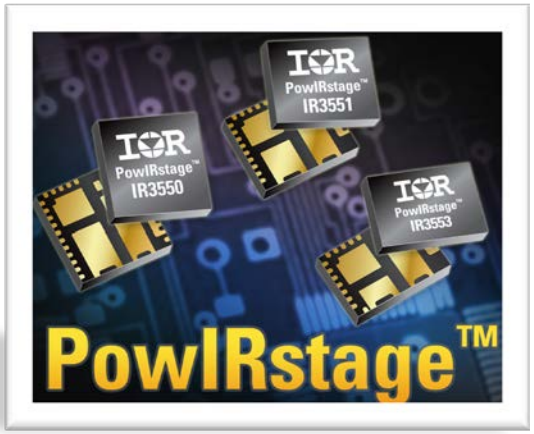
International Rectifier Trench IGBT Platforms

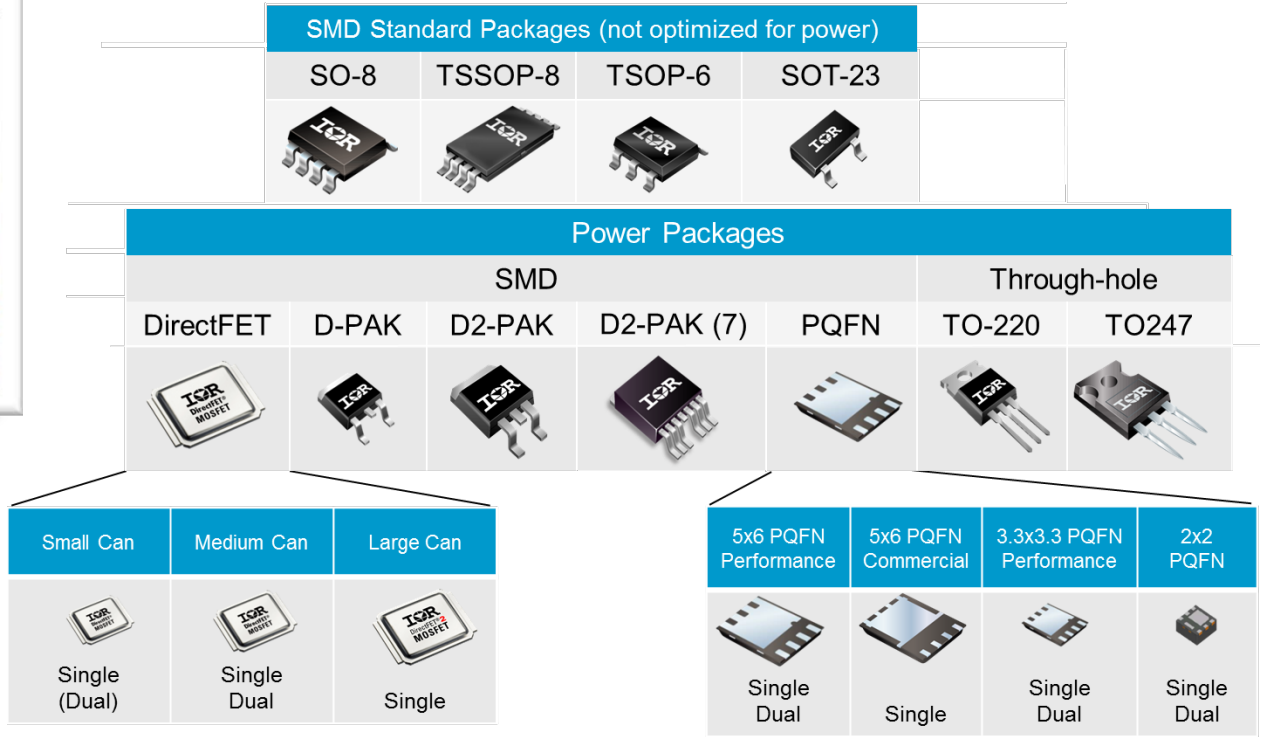
Voltage	Type	Speed	Applications	Characteristics
300V 330V	Epitaxial	U	PDP, Forklift, Welding	Very high peak current
600V 650V	Field Stop	K3	Appliance, UPS, Solar, Welding, PFC	High Frequency
		K6	Motor Drive	6 usec S.C.
	Epitaxial	U	PDP	Very high peak current
		F	Appliance	Fsw < 10 kHz
		S	50 or 60Hz	Very low Vceon
1200V	Field Stop	U	UPS, Welding, Solar, PFC	High Frequency
		K6	Electric Vehicle	6 usec S.C.
		K10	Motor Drive	10 usec S.C.

U=Ultrafast, F= Fast, S= Standard, K_x = Short Circuit x usec

Packaging Developments

Silicon improvements allow for smaller die sizes which in turn enables smaller packaging.





The packaging challenge

- Reduce the package resistance so the silicon Rds(on) improvements can be realized
- Increase the current handling capability

Packaging Innovations

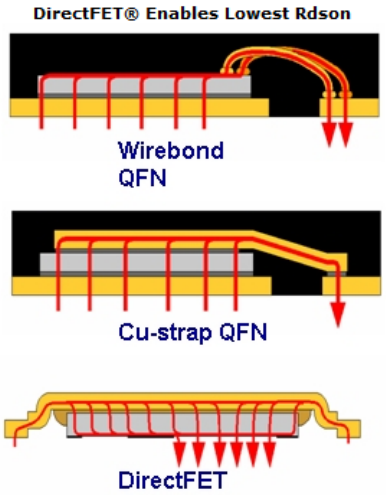
- Increase the pin count for higher current
  - 7 pins are better than 3 !

Part #	Package	Rdson Max @ 10Vgs	Qg Typ	Id max
IRFS7430-7PPBF	D2PAK-7	.78 mOhm	300 nC	240A
IRFS7430PBF	D2PAK	1.3 mOhm	300 nC	195A

SMD

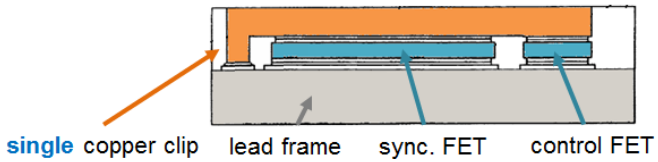
D2-PAK	D2-PAK (7)
	

- Remove the wirebonds



Dual Die Solution

IR is using a **single** clip to attach both dies:

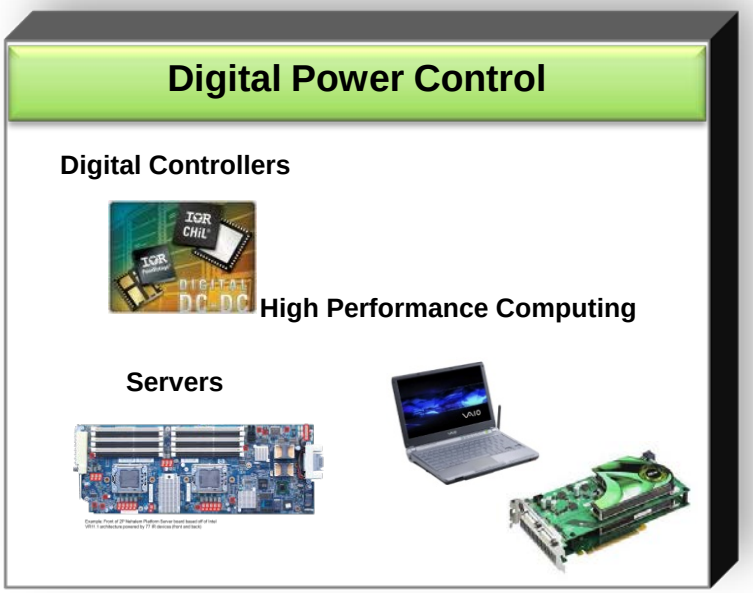


Internal view from the side

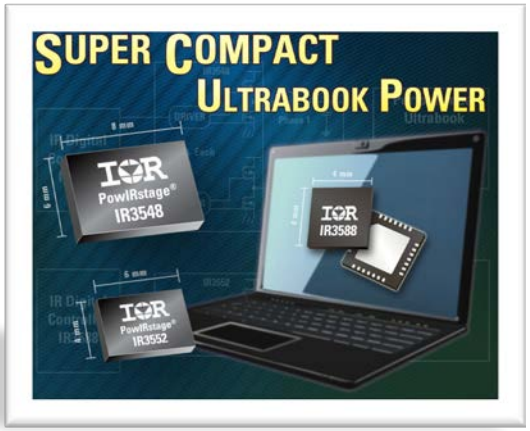
ARROW | Power Management

Five Years Out

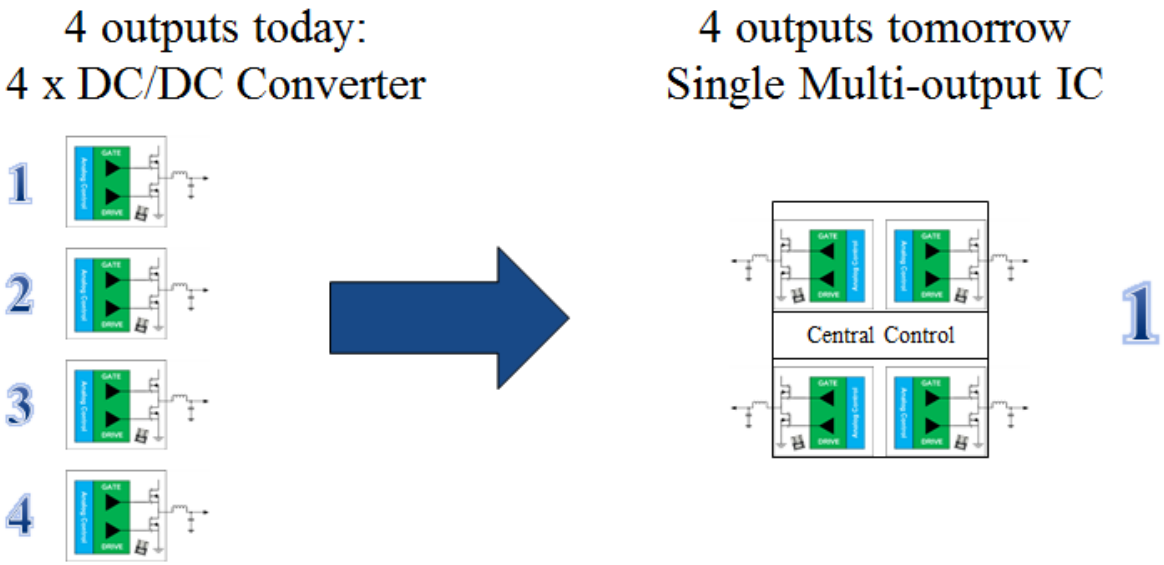
Integration of Digital Control – Driving to ALL voltage rails



- Today – Digital Control valued in high current Processor power solutions
  - Specific Processor power management interfaces (Intel SVID, others)
  - Non-linear performance for managing Transients (di/dt) and fast voltage changes (dv/dt)
  - Telemetry over I^2C or PMBus reporting Voltage, Current, Efficiency, Temperature, etc
- Challenges going forward
  - More processors and devices need complex power management to manage power states (fast sleep, wakeup, power savings) → Even lower power devices need di/dt & dv/dt control
  - Processors are changing from 150W at 1.0V to multiple voltage rails (core, I/O, DDR, etc) that ALL need power controls
  - Telemetry accuracy is critical to manage performance – even at lower currents



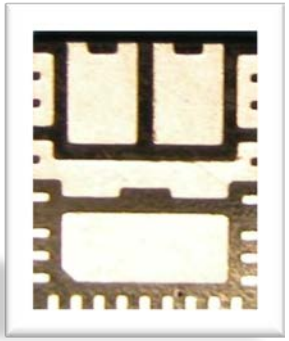
Integration of Digital Control – Driving to ALL voltage rails

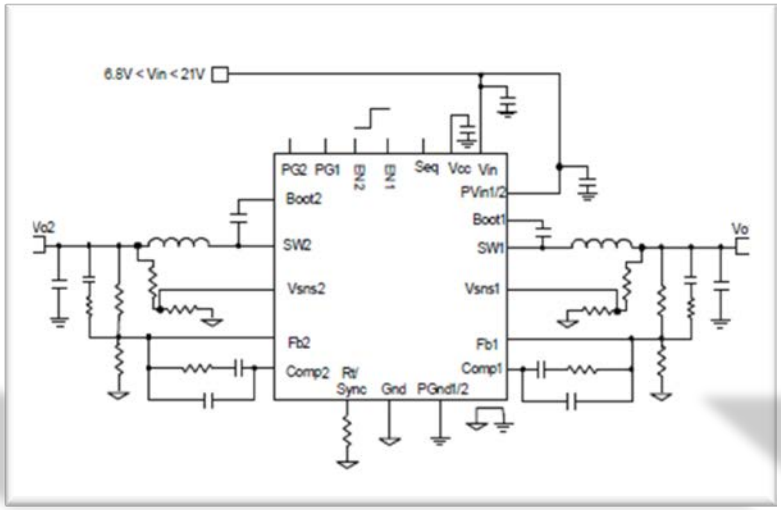


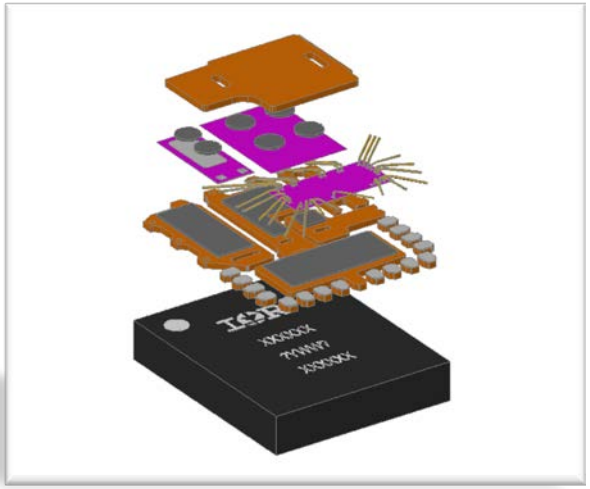
- **IR Solutions going forward**
  - Where today we offer Digital on Vcore, VDDR rails, IR will continue to develop digital solutions for every rail
    - Pure digital – 100% digital control loop, telemetry, etc. More flexible
    - Hybrid Digital – Analog control loop + Digital Wrapper: Lower Iq, simpler to use
- **IR Solutions – Related devices**
  - Intelligent Power Stages (Driver, High MOS, Low MOS) to contain Current sensing, temperature sensing, fault management
    - Plug-n-play solutions to create any complete system using combination of Monolithic digital power for lower current rails and multi-chip solutions for higher current rails

Multi-output Control – Managing Systems not Voltages

- Today – IR provides high density leading DC/DC conversion for highly efficient, dense solutions
  - IR's SupIRbuck solutions are multichip – Control IC + High MOS + Low MOS
  - Up to 2 voltages in a single device – Dual Control + 2 x High MOS + 2 x Low MOS





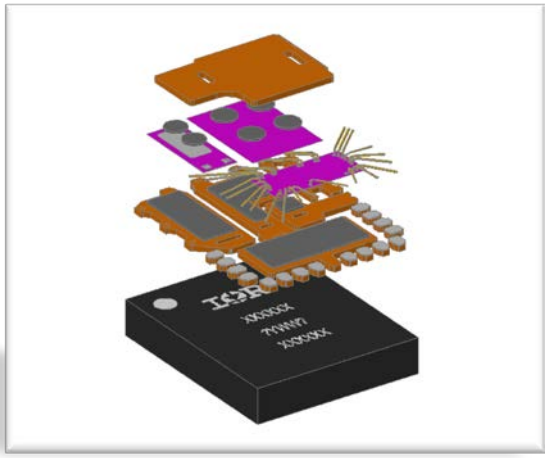


Dual Output SupIRBuck

Single Output 25A SupIRBuck

- Challenges going forward
  - To provide more than 2 voltages, multichip packaging becomes impossible (more than 5 die in a single package is not cost effective or size effective
  - Monolithic power Management ICs (PMICS) are in development
  - To be as efficient as IR's leading edge MOSFETs, a very low RDSon CMOS IC process is required

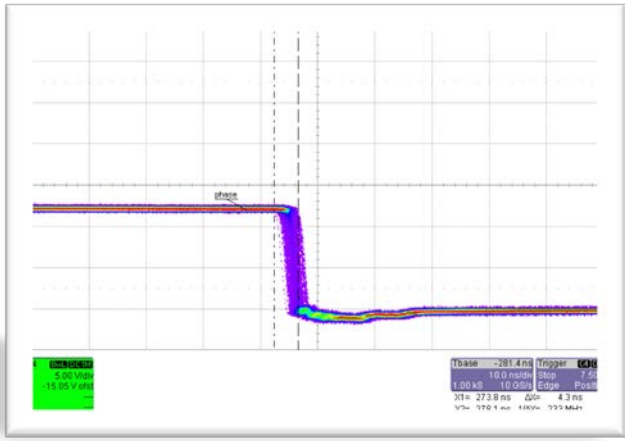
High Frequency – MOSFET & GaN based DC/DC



- Today – High Frequency switching driven by product Density
  - Efficiency vs Frequency vs Size continues to dominate Engineering Decisions
  - System/Power Engineers want to switch at least at 1MHz – but power device Efficiency requires 400-800kHz
- Challenges going forward
  - Higher Efficiency Switching devices to reduce power losses, increase DC/DC converter efficiency
    - MOSFETs with Lower RDSon, Qg, Figure of Merit (FOM) – Today's MOSFET RDSon is "package limited" where the wire bonds now dominate the RDSon
      - Continued wire-bond free packaging including copper clips, chipscale , etc.
    - Low voltage GaN devices to increase switching even further
  - When MOSFETs and / or GaN get there, how to control the switch?

500kHz → 1.5MHz → 10-20MHz

High Frequency – MOSFET & GaN based DC/DC



12Vin 1Vout 1Mhz – 4.3ns Jitter

td(on)	Turn on delay	7.8ns
tr	Rise Time	8.9ns
td(off)	Turn off delay	9.3ns
tf	Fall Time	5.3ns

- **The DC/DC Duty Cycle problem – 12V input, 1V output**
  - Today a DC/DC converter with 12V input 1V output → 10% duty cycle
    - At 1MHz, 10% duty cycle is a pulse width / on time of 100ns so VERY fast switching devices and control techniques used
    - At 10MHz, 10% duty cycle is a pulse width / on time of 10ns – by today's standards – this can't be done effectively today!
- **IR Solutions – Faster Analog Digital control & Faster devices**
  - In order to manage a 10-20MHz switching frequency, IR will continue to
    - Increase the speed of digital control but at the same time, continue to reduce quiescent current
    - Optimize Digital & Analog – Use analog blocks for high speed and digital blocks for telemetry
    - Release next-generation MOSFETs and GaN devices to continue to drive higher efficiency solutions
    - Continue RoHS6 compatible packaging development to insure zero inductance solutions for higher frequency solutions

Enabling Technology to Help Save Energy

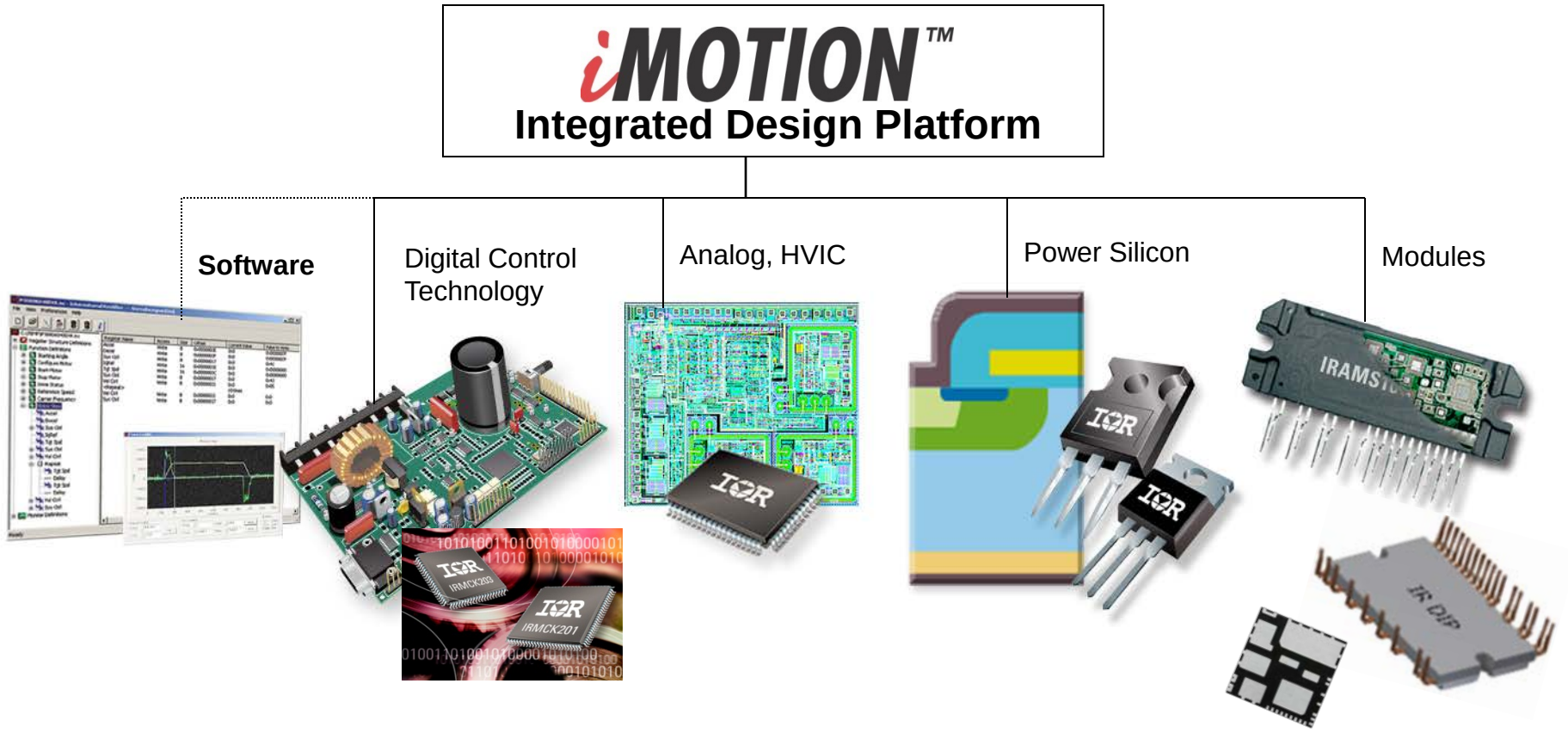
Key Differentiators

- Industry-leading analog HVICs and IGBT platforms
- Industry-leading energy saving design expertise
- Silicon packaging technology delivering superior system performance

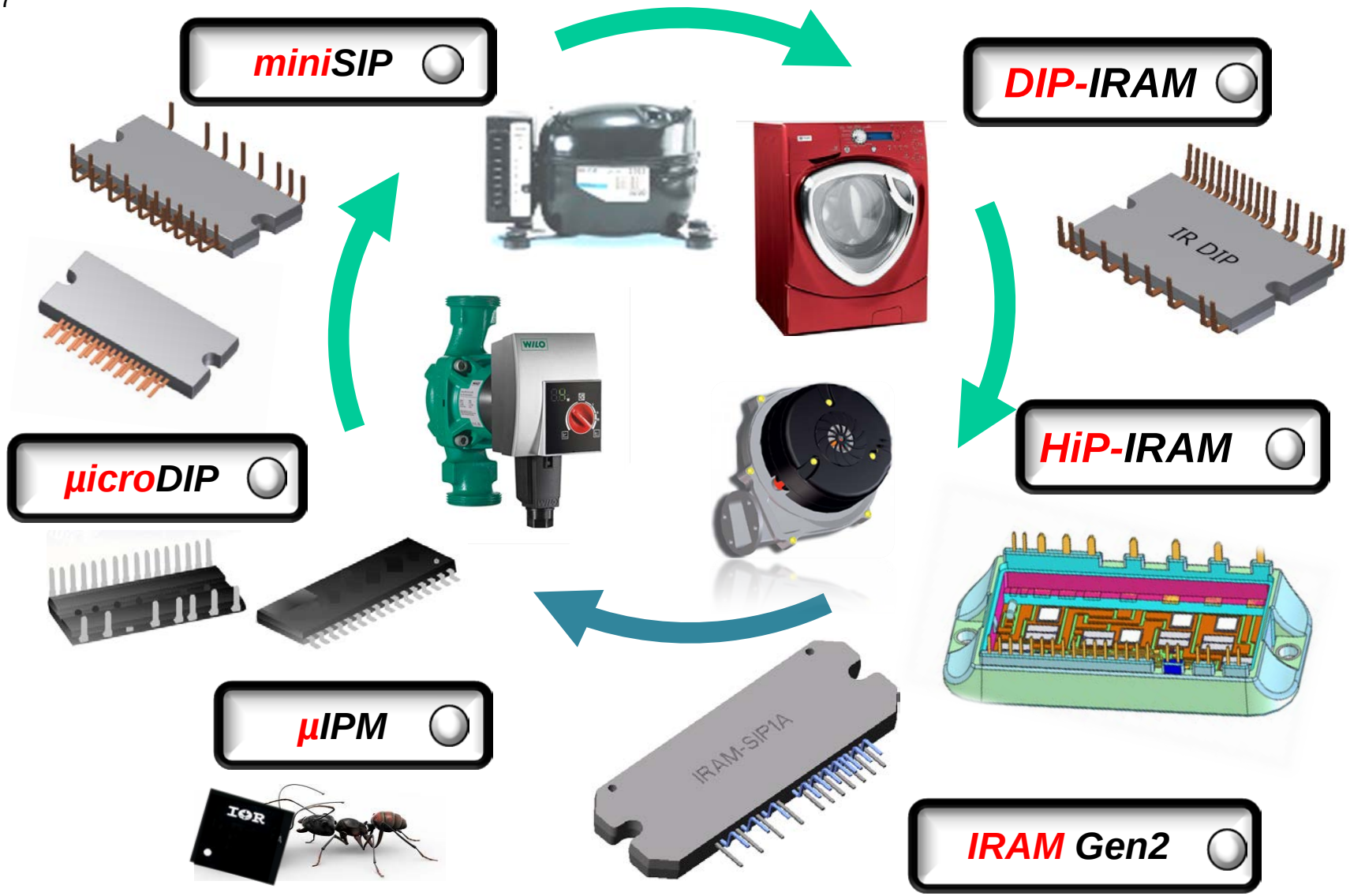
Key Products

- Digital Control ICs
- High-Voltage ICs
- IGBTs
- IRAM Integrated Power Modules

Appliances	Consumer	Industrial	Alternative Energy
			

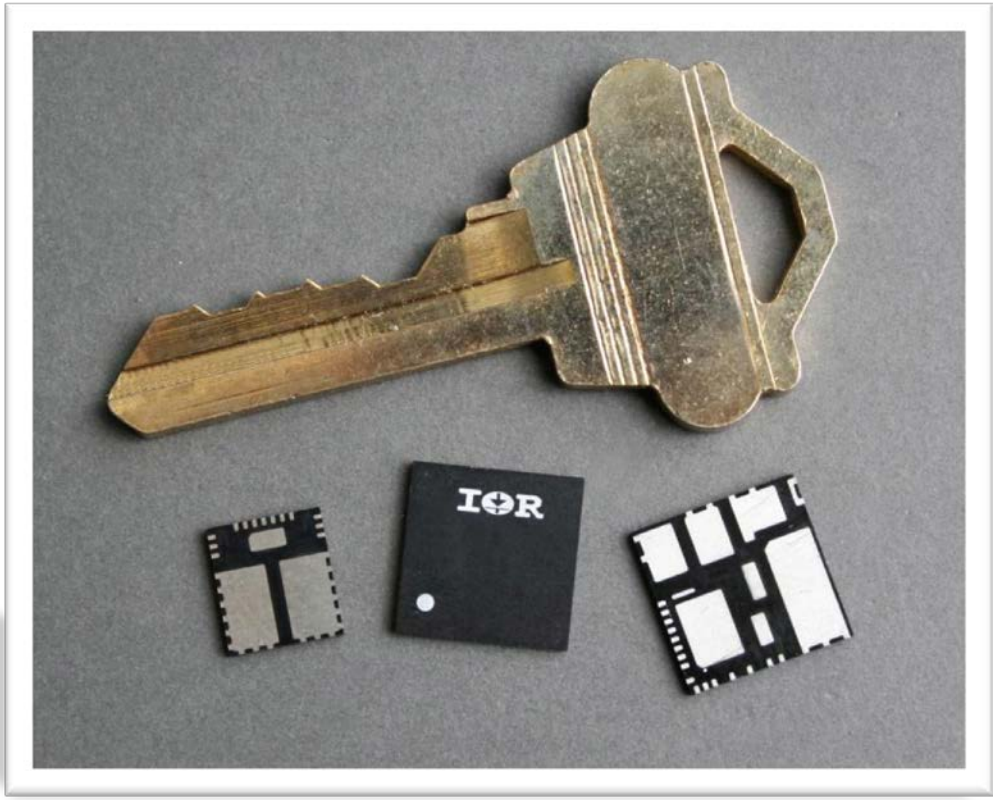

iMOTION™
Integrated Design Platform
Software
Digital Control Technology
Analog, HVIC
Power Silicon
Modules
IRMCK203
IRMCK201
IRAMS
IR DIP

The Package Roadmap



PQFN Power Modules μIPM™

- **Up to 300W load management from a PQFN package**
- Fully integrated ½-bridge &
- Full 3-phase Bridge motor control circuit solutions

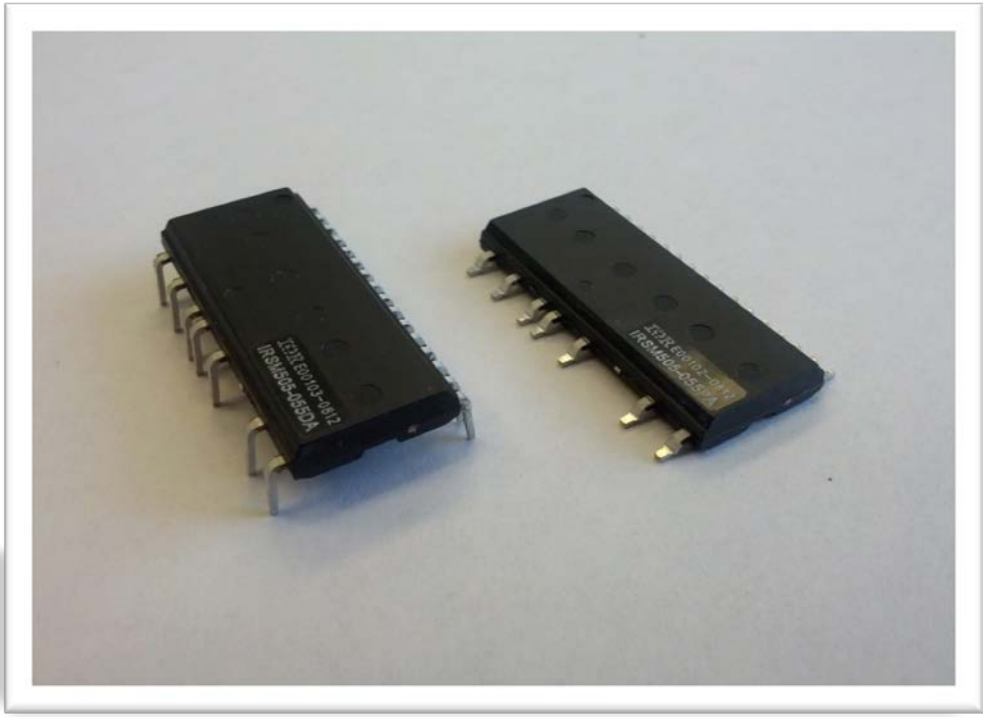


The μIPM™ Virtues

- **60% Smaller**
- **No Heat Sink**
- **Lower cost**
- **Scalable Power**
- **Scalable Solutions**

Integrated Power Module Package Expansion

- **Up to 300W load management with heatsink**
- 3x HB configuration for simpler motor control circuit solutions
- IGBT based version available up to 3A-600V



***µicro*DiP Features**

- **Pin to Pin Compatible**
- **Standard Package**
- **Scalable Power**
- **Scalable Solutions**

IPM Product Family Roadmap 2012~2015

20

Power/Performance

Year

2012 | 2013 | 2014 | 2015~2016

IR *µIPM*

3-Phase AC Inverter

- 30W – 150W 3-phase IPM
- 250V/500V, 2A – 4A DC
- QFN 12x12
- No heatsink
- Integrated bootstrap diode
- Overcurrent protection

Half-Bridge

- 300W+ ½ bridge IPM
- 500V, 6A – 8A DC
- QFN 8 x 9
- No heatsink, optional top side cooling
- Integrated bootstrap diode

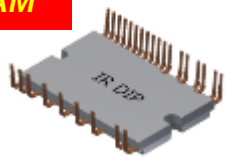
Launched at Electronica 2012

Launched at PCIM 2012

IRAM Gen2

- Pin to Pin compatible with existing IRAM
- **Exposed IMS substrate** improves thermal performance.
- **100% IR Owned** design & manufacturing lines.

IR *DiP IRAM*



- 3-phase DIP-IPM
- 6~30A 600V
- Bootstrap Function

IR miniSiP & minDiP (*SD-X*)

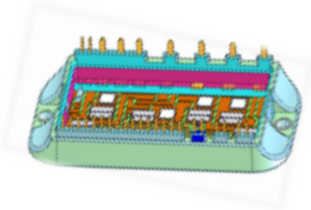
- 150 – 350W 3-phase IPM
- 250V/500V/600V
- Single 3 Phase HVIC, Bootstrap Function Built-in
- FREDFET & IGBT Version

IR *µicroDIP*

- 30W – 150W 3-phase IPM
- 250V/500V, 2A – 5A DC
- DIP23 & SOP23
- 3 HB Drivers, Bootstrap Diode Function

GaN *µIPM™*

- 300W-500W 3-phase Smart IPM

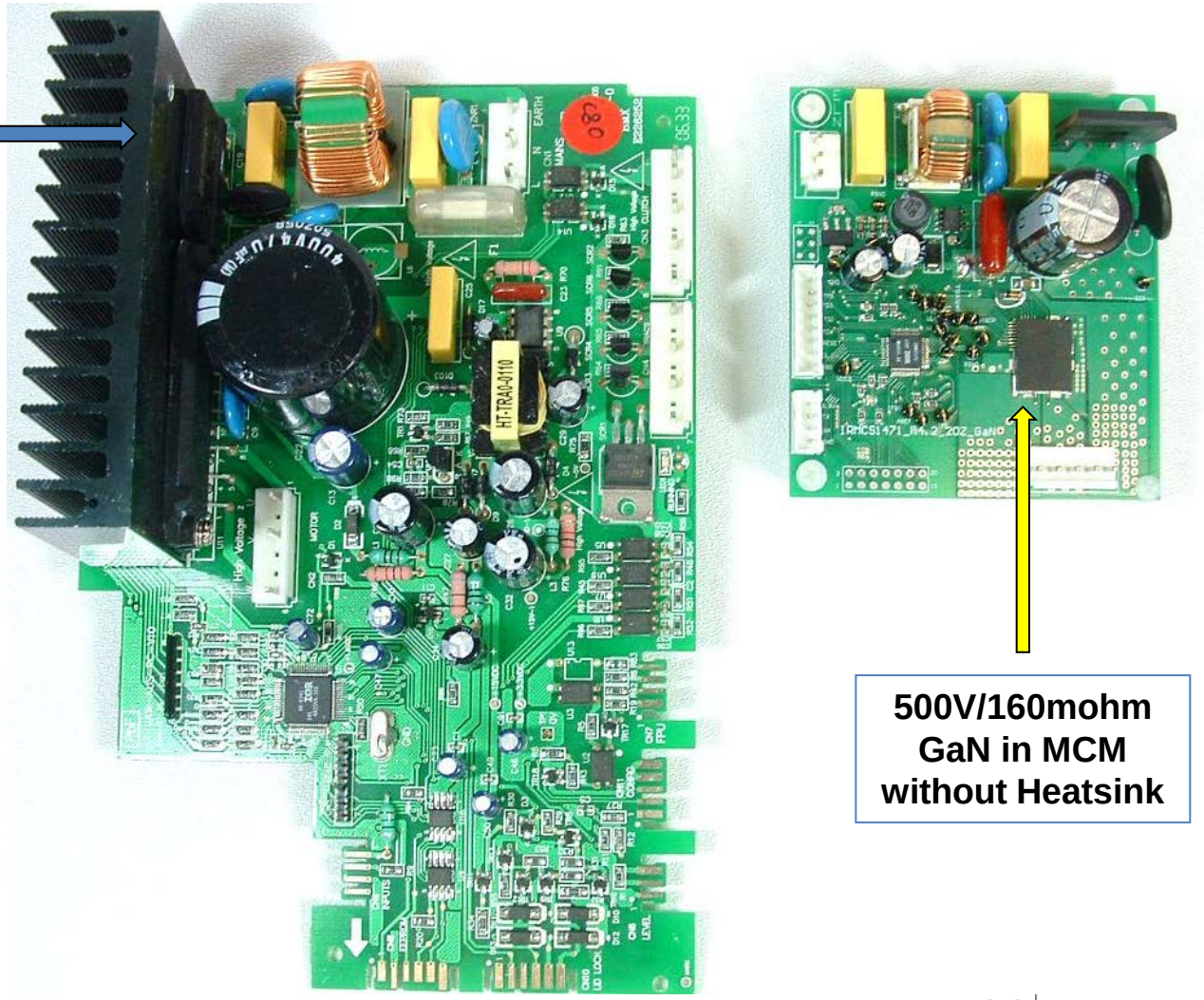


- New 1200V & 600V Industrial Modules

400W Inverter Board for Appliance

µIPM™ GaN Based Prototype

6A IRAM with Heatsink



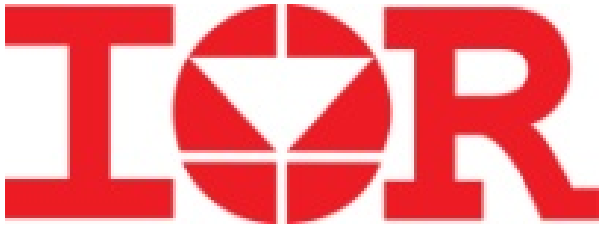
500V/160mohm GaN in MCM without Heatsink

An industry first…

Samsung 7.1 Channel Home Theater System

Model HT-F9750W features an IR Gallium Nitride powered amplifier that delivers pure sound

International Rectifier
Your Power Management Partner
Today & Five Years Out



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